CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-39

October 21, 1977

1. Name of fault: Cucamonga fault.

2. Location of fault: Mt. Baldy, Cucamonga Peak, and Devore 7½' minute quadrangles, San Bernardino County (figure 1).

3. Reason for evaluation: This fault is located within the 1977 study area of the 10-year program for fault evaluation. Holocene displacement along this fault is either implied or stated by several of the references listed below.

4. List of references:

a) Alf, R.M., 1948, A mylonite belt in the southeastern San Gabriel Mountains, California: Geological Society of America Bulletin, v. 59, p. 1101-1120. Map scale about 1:200,000.

(This report deals mainly with the ancient cataclastic rock complex that lies north of and parallel to the Cucamonga fault.)

b) Burnham, W.L., 1953, The geology and ground water conditions of the Etiwanda-Fontana area, California: unpublished Masters thesis, Claremont College, Claremont, California, 136 p. Plate I scale 1:31,680.

(His description of the Cucamonga fault (p. 52) is brief and provides little new information. He discusses in some detail the "Crawford Canyon" fault (p. 57), which apparently truncates the eastern end of the Cucamonga fault.)

c) California Division of Mines and geology, 1974, Official Map of Special Studies Zones, ~~Map~~, Devore Quadrangle. Scale 1:24,000.

(The entire extent of the Cucamonga fault has been zoned within this quadrangle.)

d) Dibblee, T.W., Jr., 1963, Geologic map of the San Antonio, Hesperia, Ontario, and San Bernardino 15' quadrangles: unpublished map. Scale 1:62,500.

(This map is not as detailed as the maps of Morton (1976) and Fife, et al (1976).)

e) Dutcher, L.C., and Garrett, A.A., 1963, Geologic and hydrologic features of the San Bernardino area, California: U.S. Geological Survey Professional Paper 1419, 114 p. Plate 1, scale 1:31,680.

(Their discussion of the Cucamonga fault (p. 36) is apparently taken almost entirely from Eckis (1928).)

f) Eckis, Rollin, 1928, Alluvial fans of the Cucamonga district, southern California: Journal of Geology, v. 36, no. 3, p. 224-247. Map scale about 1:160,000.

(He describes the alluvial fans, their genesis, and their relationship to the range front. He states (p. 231) that no important east-west faults were found in the bedrock north of the Cucamonga scarp. He implies Holocene activity along the Cucamonga fault, but provides no hard evidence.)

g) Eckis, Rollin, 1934, South coastal basin investigation, geology and ground water storage capacity of valley fill: California Division of Water Resources Bulletin 45, 279 p. Maps A, C, and E. Scale about 1:150,000.

(He adds no significant new information beyond what he provides in Eckis (1928).)

h) Fife, D.L., Rodgers, D.A., Chase, G.W., Chapman, R.H., and Sprotte, E.C., 1976, Geologic hazards in southwestern San Bernardino County, California: California Division of Mines and Geology Special Report 113, 40 pages. Map scale 1:48,000.

(He states that the fault is active (p. 7), but gives no hard evidence. Mapping is fairly good, the faults are annotated, but Morton's (1976) map is generally more useful.)

i) French, J.J., 1966, Progress report on proposed ground-water studies in the Lytle Creek-San Sevaine area, upper Santa Ana Valley, California: U.S. Geological Survey, Water Resources Division Open File Report, 10 pages. Map scale 1:24,000.

(This report adds no new information beyond what was provided by earlier workers.)

j) Herber, L.J., 1976, The Cucamonga fault, <u>In</u> M.L. Stout, editor, Geologic guide to the San Bernardino Mountains, southern California: Association of Engineering Geologists, southern California Section Annual Spring Field Trip, p. 32-34.

(He discusses some 14-foot deep trenches across one of the scarps. Within the trenches there was no conclusive evidence for the existence of the fault; the material trenched was "poorly bedded, largely uncemented, coarse sandy gravel.")

k) Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1. Scale 1:750,000.

l) Lamar, D.L., Merifield, P.M., and Proctor, R.J., 1973, Earthquake recurrence intervals on major faults in southern California, in D.E. Moran, J.E. Slosson, R.O. Stone, and C.A. Yelverton, editors, Geology, seismicity, and environmental impact: Association of Engineering Geologists Special Publication, p. 265-276. Map scale about 1:1,250,000.

(This report deals primarily with the concept of and calculation of recurrence intervals. They state (p. 273) that part of the Cucamonga fault may have undergone historic surface displacement.)

m) Morton, D.M., 1976, Geologic map of the Cucamonga fault zone between San Antonio Canyon and Cajon Creek, San Gabriel Mountains, southern California: U.S. Geological Survey Open File Report 76-726. Scale 1:24,000.

(This map is probably the most useful for A-P zoning. Holocene map units are shown as offset by Cucamonga fault scarps.)

n) Morton, D.M., 1977, Annotations added to the map of Open File Report 76-726: personal communication.

(The annotations provide a relative ordering of recency of displacement along the various traces of the fault.)

o) Morton, D.M., and Yerkes, R.F., 1974, Spectacular scarps of the frontal fault system, eastern San Gabriel Mountains, southern California: Geological Society of America Abstracts with Programs, v. 6, no. 3, p. 223. No map.

(They suggest that the formation of the Cucamonga scarps may have been accompanied by earthquakes with strength as great as M8.)

p) Real, C.R., and Cramer, C., 1977, Seismicity near Cucamonga fault, 1932 to 1976 California Division of Mines and Geology, unpublished maps and memorandum. Map scale 1:250,000.

q) Wallace, R.E., 1977, Profiles and ages of young fault scarps, north-central Nevada: Geological Society of America Bulletin, v. 88, p. 1267-1281.

5. Summary of available data:

The Cucamonga fault is the easternmost portion of a long string of faults that bounds the San Gabriel Mountains on the south (figure 1). In this report, the Cucamonga fault is defined as being the same as is shown on the map of Morton (1976). It is the principal bounding fault along the range front of the San Gabriel Mountains from San Antonio Wash on the west to Lytle Creek in the east (figure 4), a distance of about 22 km (13.5 miles).

The Cucamonga fault is actually a fault zone, generally consisting of two or more surface traces occurring within a zone as much as 1 km wide. The surface traces are characterized by south-facing scarps. The geomorphology of these scarps is best described by Eckis (1928). The scarps that are entirely within alluvium range from 3 m to 23 m (10 to 75 feet) in height. In the areas between the larger canyons, where the fault bounds the crystalline basement rock, the scarps are as high as 75 m (250 feet). The surface traces are also [redacted] locally characterized by actual exposures of the crystalline basement rock thrust over the alluvial strata.

The literature is not consistent regarding the attitude of the fault planes. Eckis (1928, p. 246) states, "Nearly vertical faults are indicated." Burnham (1953, p. 52) states, "The northern branch...is exposed in both walls of East Etiwanda Canyon where it dips 65 degrees northward..." Morton and Yerkes (1974) indicate that the faults dip 10 to 65 degrees to the north. Morton's (1976) map shows numerous fault attitudes along most of the fault traces. These are typically in the 30 to 45 degree range, dipping north. He shows no dips as steep as 65 degrees, however, on any of the fault traces crossing East Etiwanda Canyon.

The sense of fault movement, in most of the literature, is either stated or implied to be reverse or thrust with the north side upthrown. Fife and others (1976, p. 7) call the Cucamonga fault a left-lateral reverse fault. The south-facing scarps of course support the reverse or thrust character of the fault. Nowhere in the literature, however, is any direct evidence given to support the contention that the Cucamonga fault is or was a lateral fault. The vertical separation along the Cucamonga fault during Quaternary time has probably been at least 2000 m. Fife and others (1976) state:

> The relief between the crest of the San Gabriel Mountains and the base of alluvium near Ontario is more than 10,000 feet (3,000 m). The alluvium averages more than 800 feet (244 m) thick in the central area of the basin, and just northeast of Ontario the maximum thickness is more than 1,300 feet (376 m).

The Cucamonga fault traces and their accompanying scarps, as mapped (see Morton, 1976) are quite discontinuous. No scarps cross the youngest depositional surfaces. These surfaces include the modern alluvium of the entrenched drainages, and the surfaces of the fans that have not yet been dissected. There are no scarps across the Deer Canyon fan for a distance of nearly 2 km. To the west of Cucamonga Canyon, the Cucamonga fault is expressed by only one mapped trace, a low scarp that loses its definition in the area of San Antonio Heights. Morton (1976) shows only about 300 m of scarp length to the west of Cucamonga Wash, and then dots the fault for another 2.4 km to the west-southwest. Eckis (1928, figure 4) also shows the fault scarp dying out several hundred meters west of Cucamonga Wash. Morton (1976) shows the Cucamonga fault terminating on the east at a point very close to the northwest-trending Duncan Canyon fault, about 1.5 km west of Lytle Creek. Burnham (1953, p. 58) states that this fault (which he calls the "Crawford Canyon" fault) truncates the Cucamonga fault. This he shows on a large scale map (figure 12, p. 61).

Most of the references listed above imply that the Cucamonga fault, or at least some of its traces, are active; some of the references do not deal with this question at all, but none state or imply that the fault (or zone) is not active. Fife and others (1976, p. 7) state that the Cucamonga fault is active. Lamar and others (1973, p. 273) state that part of the Cucamonga fault may have undergone historic surface displacement.

The information in the literature regarding the recency of faulting is not conclusive, however. None of the writers define "active" or "recent." Furthermore, all of their arguments for recency of faulting are based only on inferences, which include one or more of the following: (1) the scarps are youthful appearing, therefore, the faulting has been recent; (2) the alluvium cut by the fault is presumed to be of Holocene age, so therefore, three have been Holocene faulting, and (3) the 1971 San Fernando earthquake showed that the San Gabriel frontal fault system is active, therefore, the Cucamonga fault is active. Nowhere in the literature, however, are any of these inferences substantiated by direct evidence. Specifically, no studies have been made:

(1) to determine the relationship of the scarp morphology to the age of the most recent surface displacement along the Cucamonga scarps, (2) to determine the age of the youngest alluvial material cut by the fault (or the oldest alluvium not cut by the fault), and (3) to determine if the Cucamonga fault is part of the same structural system as the San Fernando fault, and if so, should recent activity on one part of a fault system require recent activity on another part of the system 60 km away? D.M. Morton (personal communication, 10/7/77) states that he has measured maximum slope angles of 27 to 31 degrees on the more youthful-appearing scarps cutting alluvium. He compared these values to the work of Wallace (1977), and says he believes the most recent significant offset occurred about 700 years ago (see figure 5).

The seismicity maps (figures 2 and 3) show the distribution of earthquake epicenters since 1932 (Real and Cramer, 1977). The 1932-1973 map (figure 2) shows little pattern related to the Cucamonga fault, but the 1974-1976 map (figure 3) shows a N75E-trending pattern of weak seismicity occurring from 2 km to 4 km north of the Cucamonga fault. If the Cucamonga fault zone dips northward beneath the range front at an angle ranging from 35 to 60 degrees, then these epicenters could represent hypocenters on the fault at a depth of 2 km to 4 km. The locations of these seismic events are only resolved to within several kilometers, however, so no strict intrepretations can be made at this time.

6. <u>Interpretation of aerial photos:</u> None.

7. <u>Field observations:</u> None this year. I spent one day in the field in 1976 with Doug Morton, looking at the more salient features of the fault zone. I can confirm that many of the scarps are very well defined.

8. <u>Conclusions:</u>

Most of the scarps (those color-coded red on figure 4) are well-defined. Some of the other faults are locally exposed in stream cuts, and therefore can be said to be well-defined. The references are generally not specific about the locations of these exposures, however. Morton (1976) shows many fault attitudes on his map, which implies that there are fault exposures at those places. Where the fault traces pass beneath younger alluvium, and there is no scarp, the fault location will have to be inferred. This may present a problem, for instance, at Deer Canyon where the fault trace(s) are buried beneath the alluvium of the active fan surface for a horizontal distance of nearly 2 km.

Based on the references, and the personal communication with Morton (19/7/77) most or all of the fault traces color-coded red on figure 4 must be considered to be of Holocene age. The references do not give any information regarding the recency of movement along the faults that are seen to cut only bedrock or older alluvium.

9. <u>Recommendations:</u>

My tentative recommendation is that the fault traces color-coded red on figure 2 should be zoned. Probably some of the other traces will also warrant zoning, but at least a small amount of aerial photo study and field examination will be required to make those determinations. I am uncertain at this time as to what width of zoning to recommend; this also will have to await the completion of aerial photo and field examinations.

10. <u>Investigating geologist's name and date:</u>

I agree with recommendation to zone and to do additional work. Give this a high priority. Also, check faults already zoned in Devore qd for possibly zone re-evaluation.
EWH
10/25/77

Drew P. Smith
DREW P. SMITH
Geologist
October 21, 1977

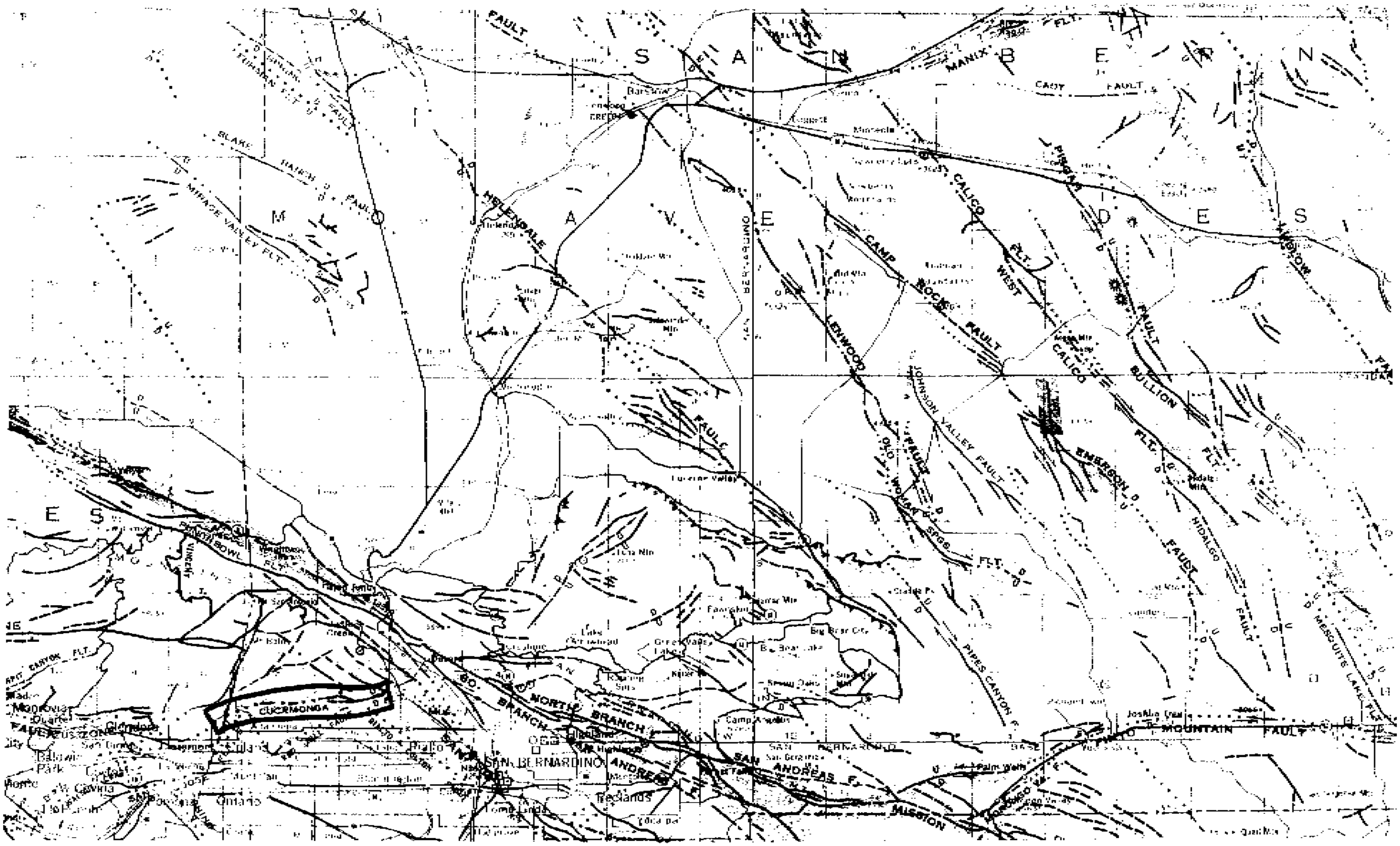


Figure 1. Index map showing location of the Cucamonga fault. Map is modified from Jennings (1975).

FER 398

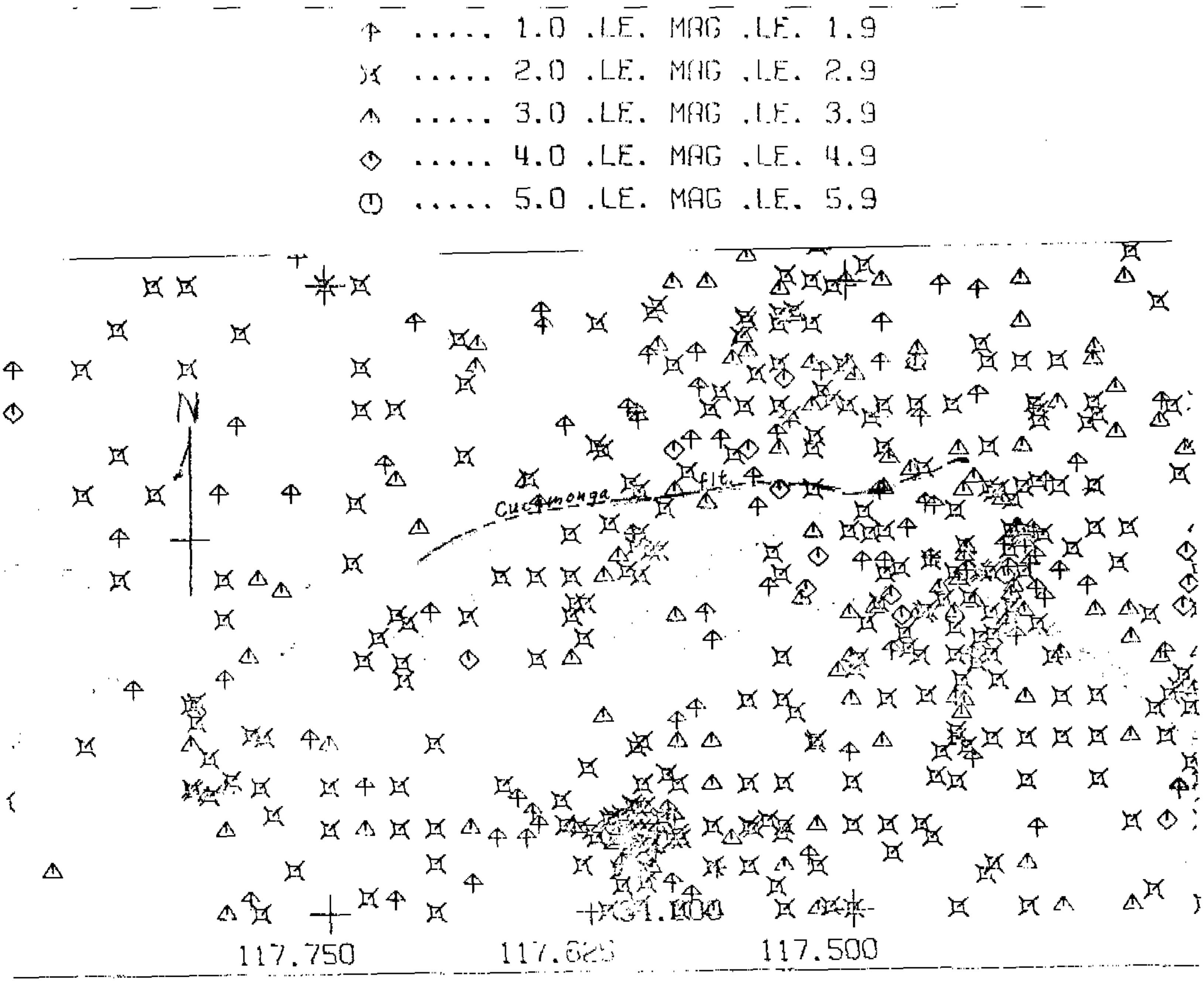
Figure 2. (From Real and Cramer, 1977)

SEISMICITY NEAR CUCAMONGA FAULT 1932-1973

TRANSVERSE MERCATOR PROJECTION

Scale 1:250,000

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS



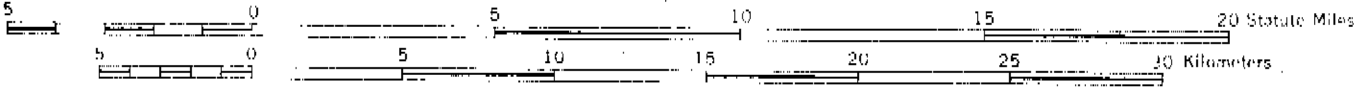
FER 598

Figure 2. (From Real and Cramer, 1977)

SEISMICITY NEAR CUCAMONGA FAULT 1932-1973

TRANSVERSE MERCATOR PROJECTION

Scale 1:250,000



CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

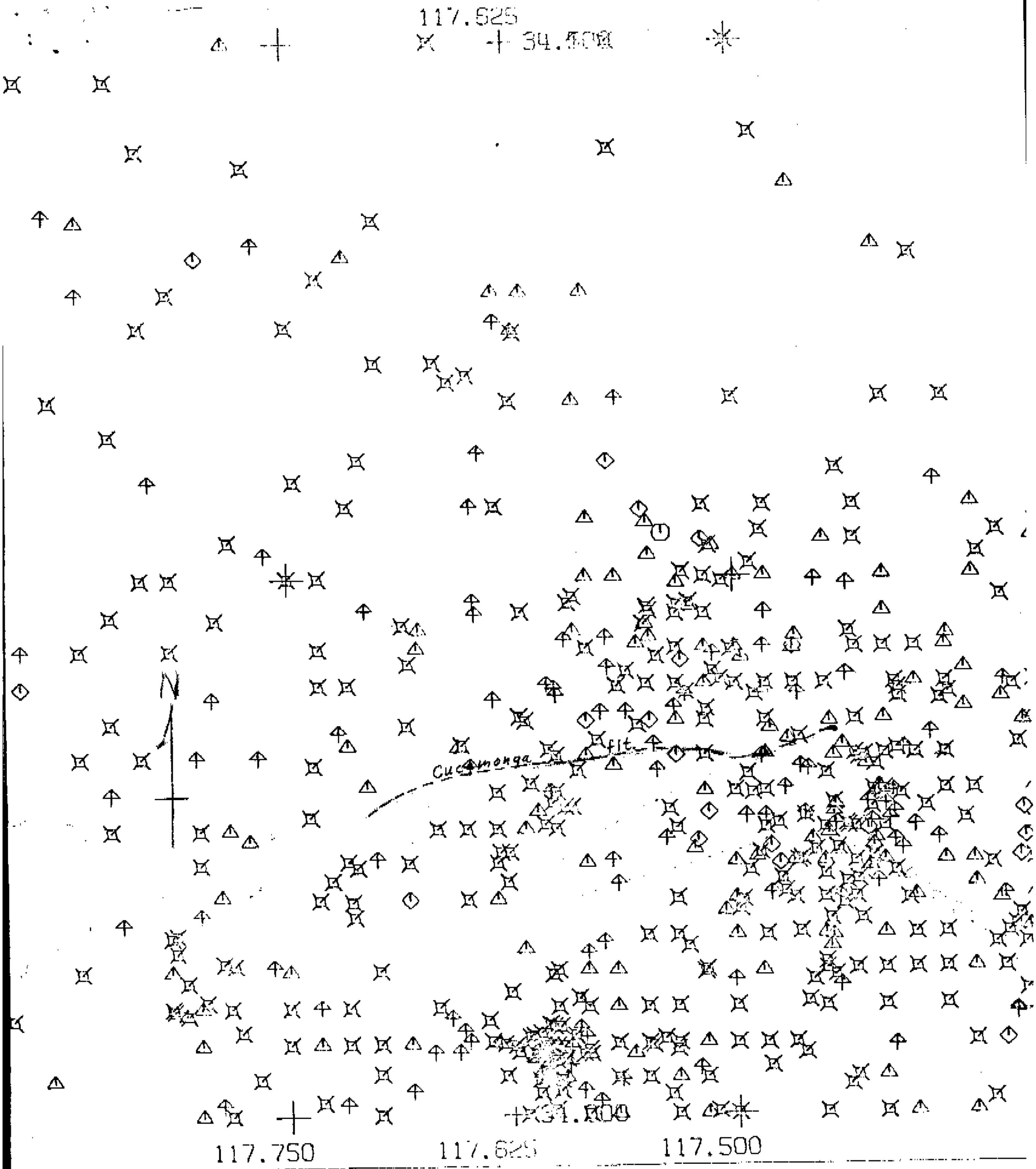
..... 1.0 .LE. MAG .LE. 1.9

..... 2.0 .LE. MAG .LE. 2.9

..... 3.0 .LE. MAG .LE. 3.9

..... 4.0 .LE. MAG .LE. 4.9

..... 5.0 .LE. MAG .LE. 5.9


117.625
N
Cucamonga flt.
117.750
117.625
117.500

FER 39#

Figure 3. (From Real and Cramer, 1977)

SEISMICITY NEAR CUCAMONGA FAULT 1974-1976

TRANSVERSE MERCATOR PROJECTION

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

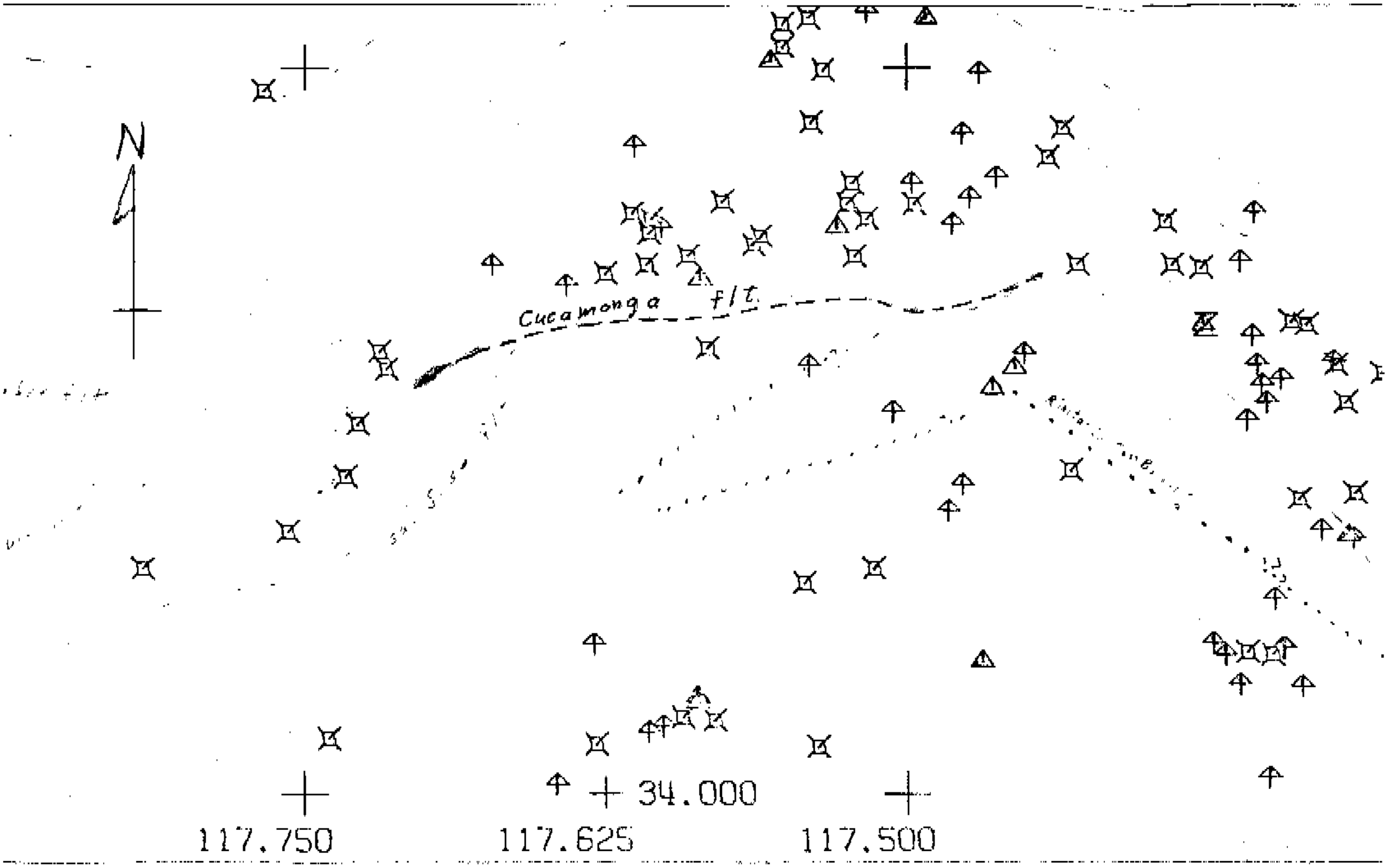
CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

Z ..... MAG .EQ. 0.0

..... 1.0 .LE. MAG .LE. 1.9

..... 2.0 .LE. MAG .LE. 2.9

..... 3.0 .LE. MAG .LE. 3.9



No. 300

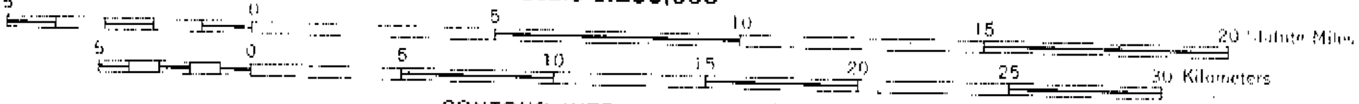
FER 394

Figure 3. (From Real and Cramer, 1977)

SEISMICITY NEAR CUCAMONGA FAULT 1974-1976

TRANSVERSE MERCATOR PROJECTION

Scale 1:250,000



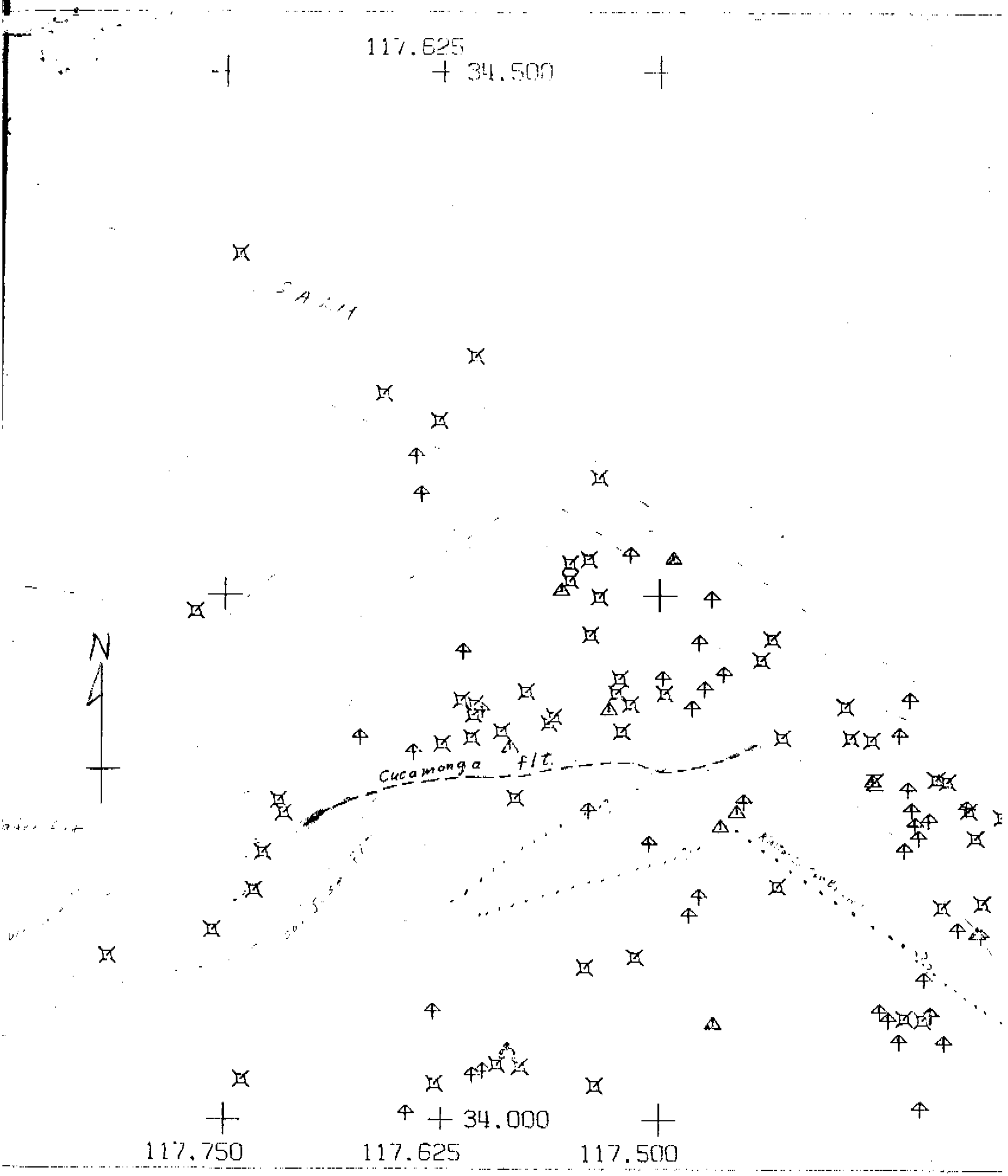
CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

Z ..... MAG .EQ. 0.0

↑ ..... 1.0 .LE. MAG .LE. 1.9

⌧ ..... 2.0 .LE. MAG .LE. 2.9

⚠ ..... 3.0 .LE. MAG .LE. 3.9


117.625
34.500
SAAH
N
Cucamonga flt.
34.000
117.750
117.625
117.500

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FER 39a

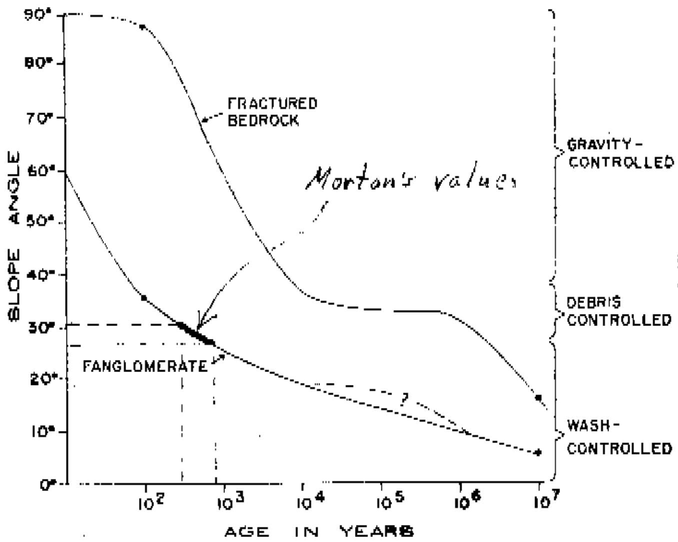

Figure 12. Limits of principal slope angle versus age of fault scarp.

Figure 5. Figure 12 of Wallace (1977) showing relationship between maximum slope angle and age of the scarp. Morton's (personal communication, 10/7/77) maximum slope values for younger scarps in alluvium are added by the writer.